Wireless Data Acquisition for Monitoring, Fault Detection and Diagnostics for Package Roof-top HVAC Units

Michael R. Brambley, Ph.D. ASHRAE Member
Pacific Northwest National Laboratory
Richland, WA 99362

michael.brambley@pnl.gov

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Overview of Presentation

- Why wireless?
- Objectives and focus of project
- Wireless for package rooftop HVAC
- Systems tested
- Information from data
- Costs
- Interim results and Conclusions

Why Wireless?

- You can't control and maintain what you don't measure and monitor
- Sensing is the foundation for good operation, control and maintenance—it's an enabling technology—but it's too expensive ($200 to >$1000 per point)
- Wiring represents 20% to 80% of a sensor point in commercial buildings
- Cost savings: substitute technology for labor for installation and servicing
- Eliminate the wires to reduce the cost and promote the use of more sensing in buildings—ultimately ubiquitous sensing
- More sensors will enable performance monitoring, automated diagnostics, automated real-time commissioning → higher performance systems
- Application to roof-top units to serve the underserved, often poorly maintained, small to medium size commercial buildings market

Objectives and Focus of Project

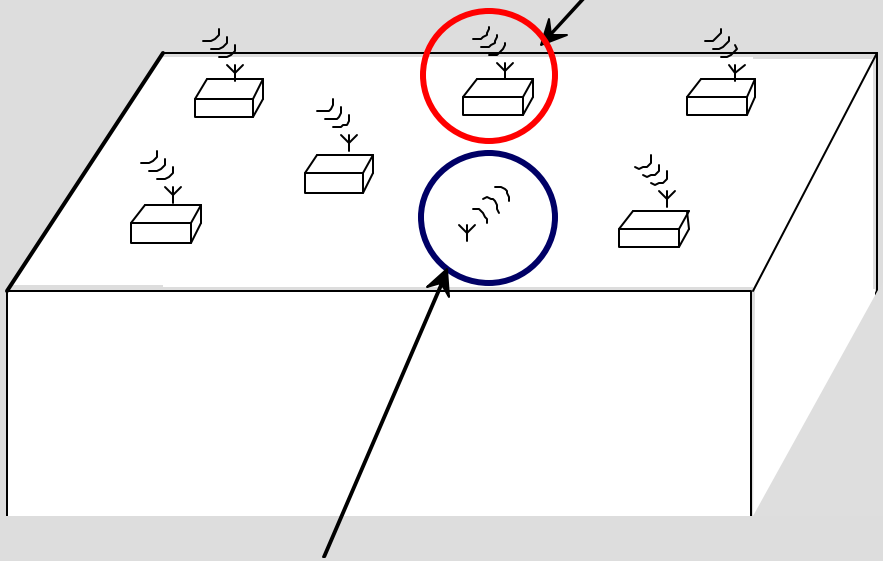
- Provide technology for improving the energy-efficiency of small- to medium-size commercial buildings
- Develop a low-cost mechanism for monitoring the performance of packaged HVAC equipment
- Develop wireless data collection capability to support tools to help HVAC operators and servicers improve maintenance while simultaneously reducing the costs of operation and service
- Break down the barriers to use of wireless technology and greater monitoring of energy using systems in small commercial buildings

Approach

- Assess commercially-available wireless technology for suitability to commercial-building applications
- Reduce cost by adapting and developing underlying wireless technology that matches the needs of building applications
- Promote use of wireless sensors and controls in buildings industry through proof-of-performance, data for decision making, guidance on use, transfer of technology to commercialization
- Integrate wireless data acquisition with automated monitoring, fault detection and diagnostics to extract actionable information from data
- Tackle the high priority, high benefit, recognized building needs first

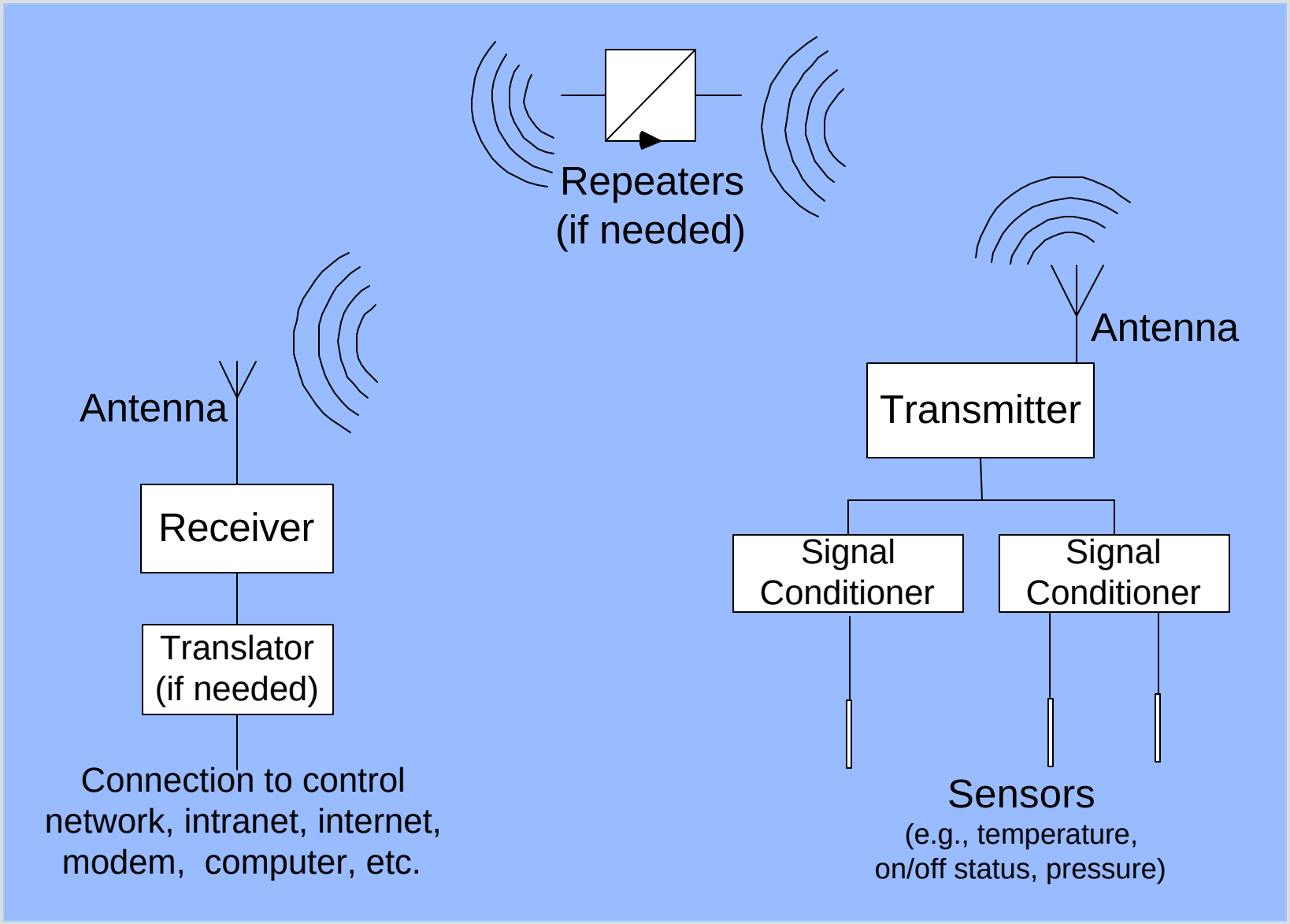
Envisioned System for Rooftop Units

Each rooftop unit with sensors and one rf transmitter



Rooftop rf receiver with connection to computer or intranet in building, internet, wireless long-distance communication, wireless to personal digital assistant, or wired telephone-line modem

A Closure Look



Requirements and Operating Conditions for Wireless Communication for Monitoring Rooftop Units

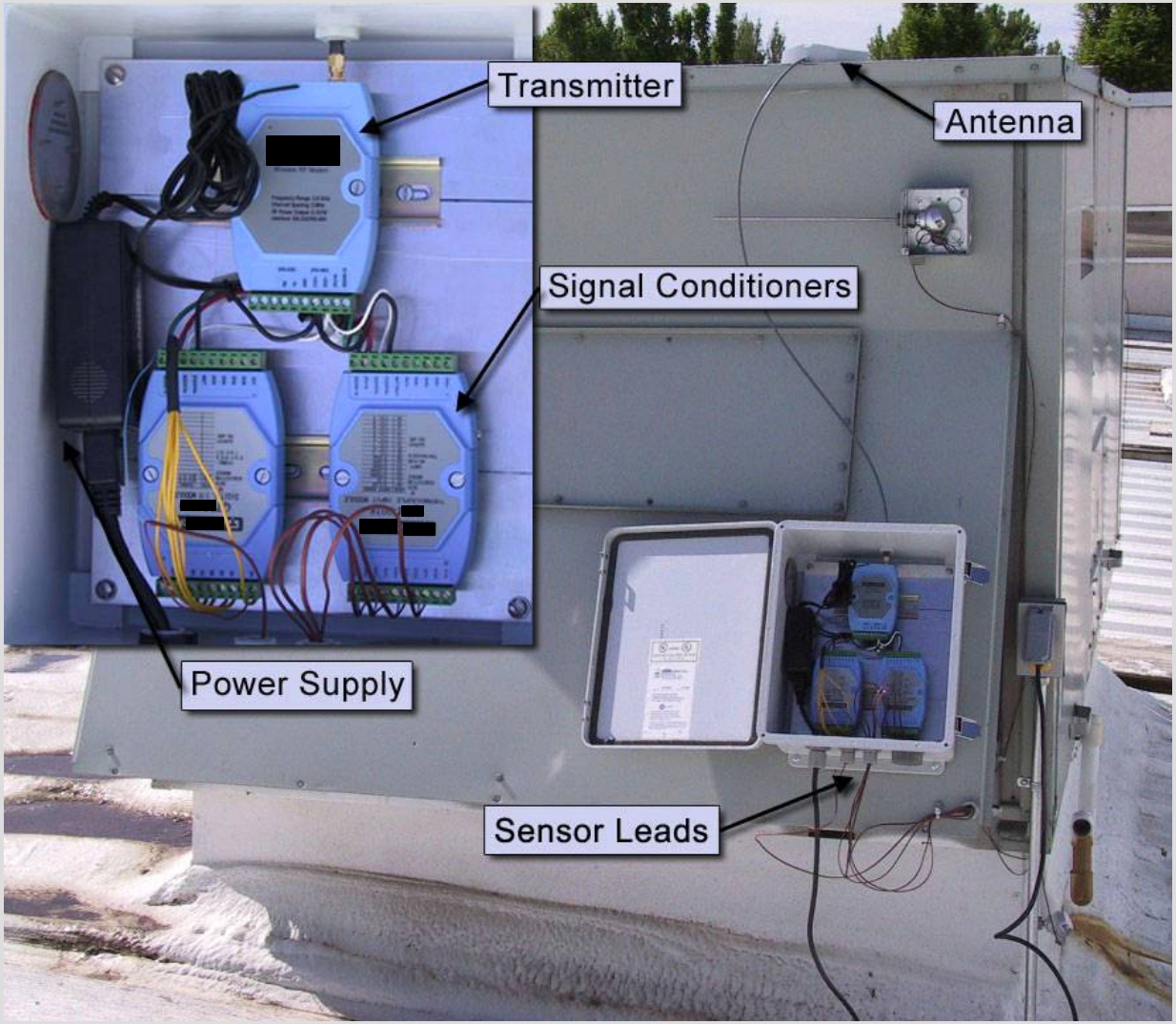
- Relatively low bandwidth required
- Line of sight can be preserved on rooftops
- Noisy machine environment
- Electrical power usually available on unit but requires wiring by an electrician
- Some components exposed to weather
- Communication distances from feet to over 100 feet
- Other rf communication devices may be present

Wireless Communication Options - Protocols

- IEEE 802.11b, a, or g - wireless Ethernet
  - computer networks
  - relatively high bandwidth – faster than needed
  - considerable power requirements
  - relatively high cost
- Bluetooth (short range wireless for appliances)
  - short range (up to 30 ft)
  - relatively high bandwidth
  - considerable power required
  - cost target $5 per node but far from it today
- IEEE 802.15.4 with Zigbee
  - low bandwidth for sensor networks
  - under development
  - significant power requirements – doesn't solve power problem but not a problem for rooftop unit applications
- Mesh networks
  - low bandwidth matched to sensor applications
  - low power required ulitimately – some require line power today
  - potential for low cost sensor nodes
  - self-configuring networks
- Various Proprietary communication protocols – some open

System Types Tested (slide 1)

- System configured from generic components – applied to one unit



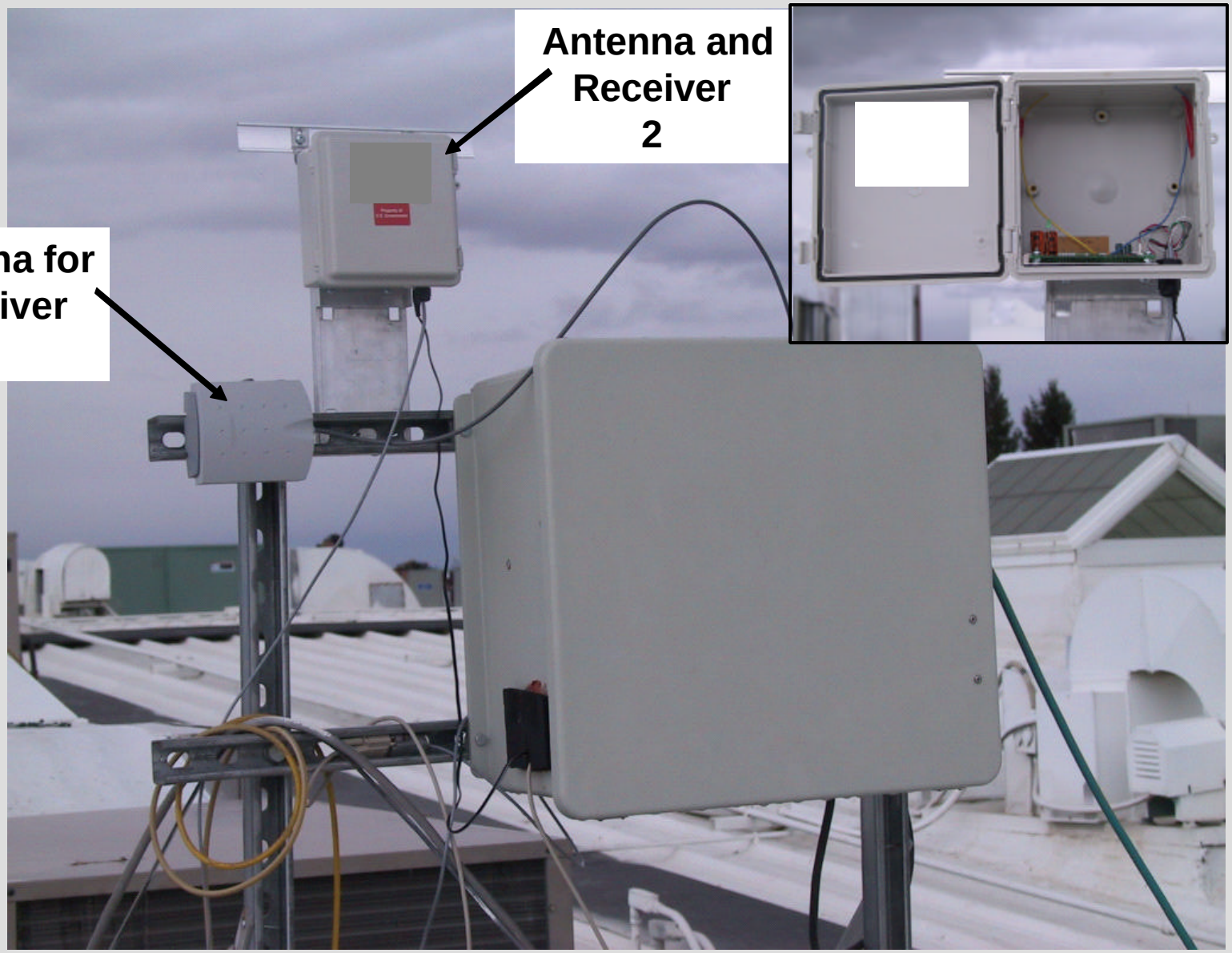
System Types Tested (slide 2)

- System specifically manufactured for package unit monitoring – applied to 4 units

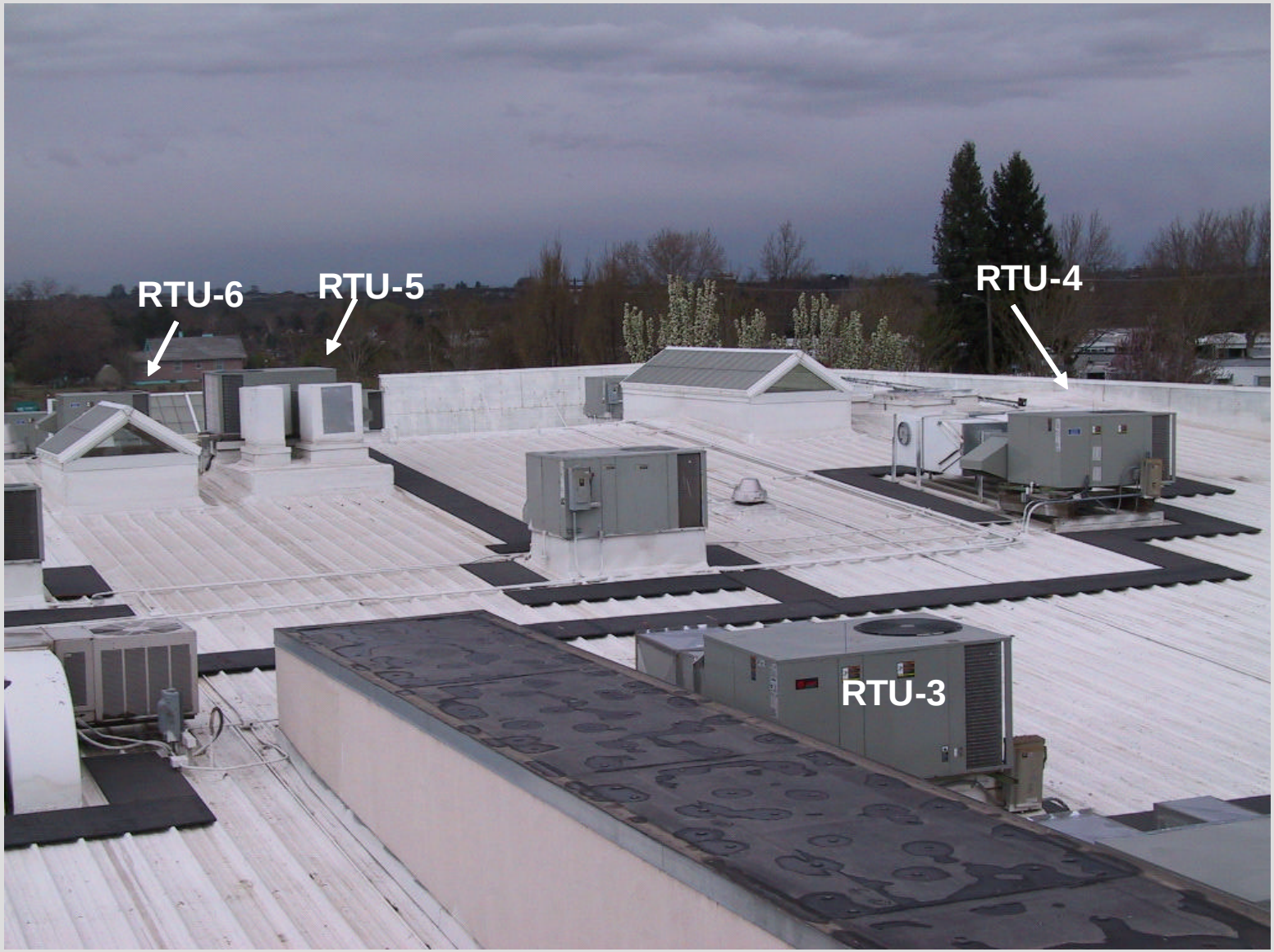
System Types Tested (slide 3)

- Close up of wireless transmitting unit with signal conditioning integrated into it

Receiver Stations



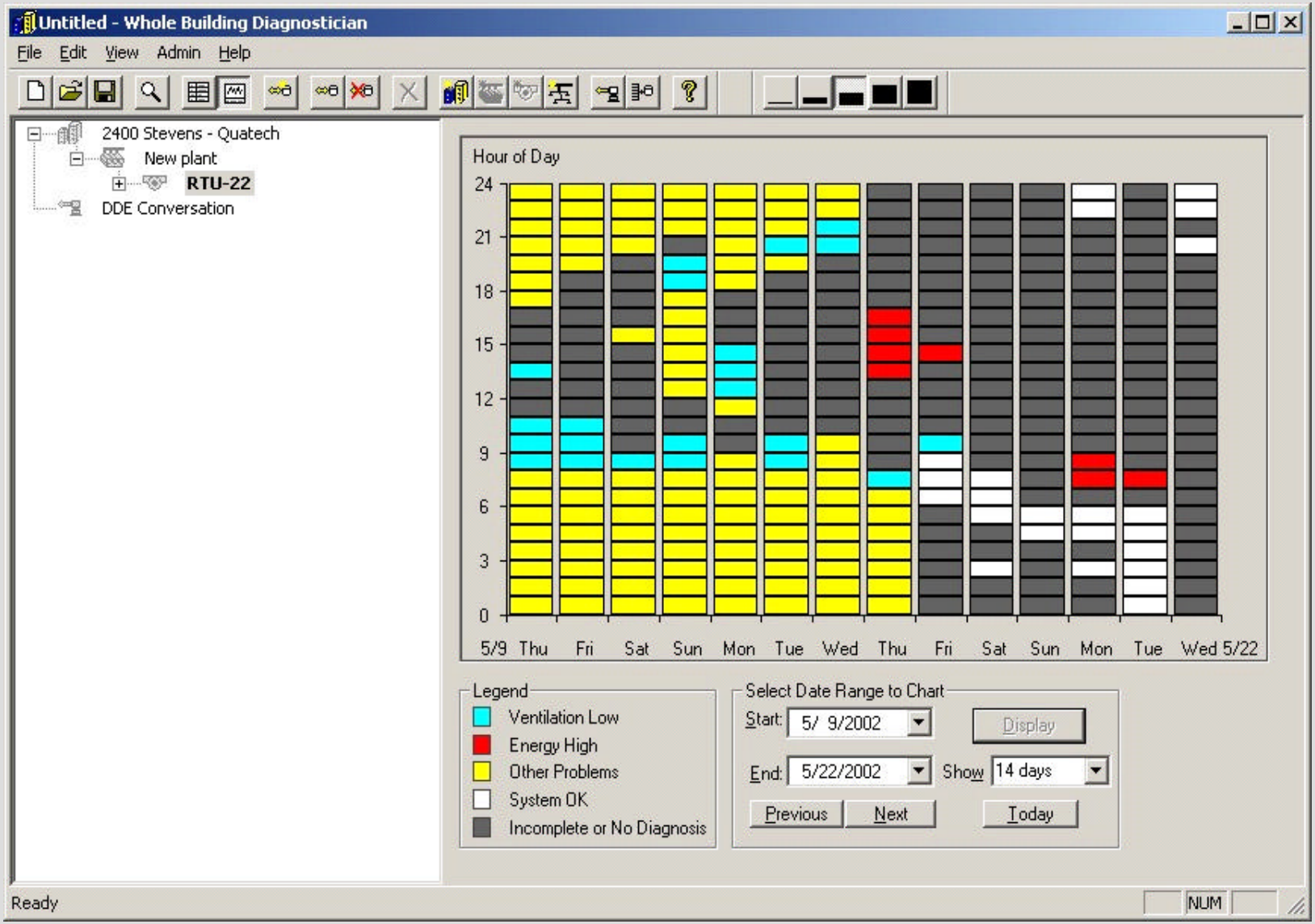
Test Environment



Data

SystemId	PollDate	FanOnFraction	Tmix	Tout	Tret	Tsupply
3	29-Mar-02	1	68.7	56.42	68.18	65.17
3	29-Mar-02	1	69.06	58.8	68.73	62.94
3	29-Mar-02	1	69.04	60.78	68.7	62.63
3	29-Mar-02	1	69.71	62.81	69.2	62.15
3	29-Mar-02	1	70.82	64.79	70.23	62.31
3	29-Mar-02	1	71.2	65.42	70.59	62.56
3	29-Mar-02	1	69.13	59.7	68.09	60.62
3	29-Mar-02	1	70.8	56.73	69.98	71.25
3	29-Mar-02	1	70.28	54.57	69.2	68.28
3	29-Mar-02	1	70.08	51.94	68.79	68.28
3	29-Mar-02	1	70.26	50.34	68.88	69.94
3	29-Mar-02	1	70.41	49.37	68.93	69.22
3	29-Mar-02	1	70.46	47.78	68.9	69.22
3	30-Mar-02	1	70.05	46.54	68.41	69.78
3	30-Mar-02	1	70.21	47.17	68.55	69.98
3	30-Mar-02	1	69.71	46.56	67.96	68.34
3	30-Mar-02	1	69.83	46.31	68.1	69.53
3	30-Mar-02	1	69.96	45.86	68.19	69.62
3	30-Mar-02	1	69.98	44.78	68.12	69.54
3	30-Mar-02	1	70.03	43.59	68.09	69.49
3	30-Mar-02	1	71.56	48.81	70.28	71.43

Converting Data Into Information
Fault Detection and Diagnostics



Cost Competitiveness

Cost Component	Cost	
	Monitoring System for Three Packaged HVAC Units	
	Wired Design	Wireless Design
Sensors	$636	$636
Wiring	$68[1]	---
Communication and signal-conditioning hardware	$1903	$1500
Labor	$1179[2]	$450
Total cost	$3786	$1950
Average cost per sensor	**$316**	**$163**

[1] Including conduit.
[2] Including installation of conduit.

Interim Findings and Conclusions

- Wireless can be competitive with wired data acquisition from package units
- Units can be monitored remotely
- Several units can be monitored using one wireless rf receiver
- Wireless can have a cost advantage over wired data acquisition for this application
- Wireless costs per sensed point decrease as the number of units monitored by a receiver increases
- Reliability of hardware is not yet proven. We have experienced problems and had difficulty obtaining good support from some manufacturers